SOLVAY
SOLVAY MINERALS

December 12, 2003

Dan Olson
WDEQ-Air Quality Division
122 W. 25th Street
Cheyenne, WY 82002

RE: Addendum to AP-0631 concerning NO_X 30-day rolling average and BACT

Dear Dan:

This correspondence further addresses AP-0631, the permit application to convert A&B Calciners (AQD #17) from gas to coal-firing. This addendum proposes the method to determine NO_X emission compliance and updates the NO_X BACT analysis with regard to Selective Non-Catalytic Reduction (SNCR).

Solvay requests that compliance with the proposed NO_X emission limit of 180 pph be determined on a continuous basis through the use of a 30-day rolling average. A continuous NO_X emission monitor will be installed on AQD #17, the common stack of A&B Calciners. The 30-day rolling average will be calculated on the average of the hourly averages for the preceding 30 days that at least one of the calciners is in operation.

WDEQ requested that SNCR, although not demonstrated on a unit similar to our calciner, be considered as a NO_X control. After investigation, it was found that SNCR is a feasible control technology. However, SNCR is not feasible as an add-on control with FGR, since the CO recirculated from the calciner from FGR reduces the SNCR efficiency to 5%, making it an economically unreasonable technology.

If you have any questions concerning this submittal, feel free to contact me at (307) 872-6571. Bill Stuble and I plan to meet with you in your Cheyenne office early next year to discuss this addendum.

Respectfully submitted,

Dolly A. Potter

Dolly A. Potter
Environmental Services Supervisor

Enclosures

cc: Tony Hoyt

Solvay Minerals, Inc.
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REVISED NO_X BACT:

Selective Non-Catalytic Reduction (SNCR) has not been identified as a NO_X control technology currently installed on a source similar to the proposed coal-fired calciners. However, SNCR vendors were contacted and they believe it is a feasible technology for our calciner furnace conditions. SNCR is a post-combustion process that reduces NO_X (NO and NO_2) by the reaction with ammonia (NH_3) to form nitrogen (N_2) and water per the following formulas:

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6\,H_2O$$

$$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6\,H_2O$$

Since urea is not poisonous and easier to handle than ammonia, it is often used as a precursor to ammonia per the following formula:

$$CO(NH_2)_2 + H_2O \rightarrow 2NH_3 + CO_2$$

The three key parameters that affect the reaction of ammonia with NO_X are flue gas temperature, reagent distribution, and CO concentration. The temperature exiting our furnace is between 1700°F and 1800°F, which is in the optimal temperature range for the reaction. A computational fluid dynamics (CFD) model can be run to locate the appropriate reagent injection sites and droplet size distribution, taking into account temperature and gas velocity.

The reaction of ammonia with NO_X is also affected by the concentration of CO in the furnace. The CO concentration in the furnace due to combustion only, is estimated to be 25 ppm. As reported in the March 6, 2003 submittal of this permit application, the CO concentration was estimated to be 522 ppm with Flue Gas Recirculation (FGR). That estimate did not account for the CO emissions associated with the calcination of trona ore, which would be recirculated as well. The May 4, 2000 stack testing of CA-1&2 (AQD #17) resulted in one-minute average CO concentrations ranging from a low of 465 ppm at 11:01 a.m. to a high of 1,772 ppm less than two hours later, at 12:52 p.m. The variation of CO emissions from the trona ore is not fully understood. The CO concentrations change with no apparent variation in ore quality or calciner operating conditions. Since the May 4, 2000 stack testing was only three one-hour runs, Solvay believes the CO concentration in the calciner off gas could rise over the 1,772 ppm that was monitored that day.

Fuel Tech, a leader in post-combustion NO_X controls, estimated the NO_X reduction efficiency of SNCR at various furnace CO concentrations as detailed in the table below:

CO (ppm)	Base NO_X rate (lb/MMBtu)	Controlled NO_X rate (lb/MMBtu)	NO_X reduction (percent)
25	0.79	0.43	46
500	0.45	0.29	36
1000	0.45	0.33	27
1500	0.45	0.43	4

As noted in the table, the performance of SNCR is affected by the CO concentration. The highest NO_X reduction calculated is 46%, which is at the lowest concentration of CO at 25ppm. The lowest NO_X reduction calculated is 4%, which is at the highest CO concentration considered, 1500 ppm. If flue gas was recirculated from the furnace only, not the calciner exhaust, the approximate 500 ppm CO would result in an SNCR efficiency of 35%. However, since the function of FGR is to reduce thermal NO_X through the lowering of the flame temperature and minimized O_2 concentrations, the flue gas temperature from the furnace of 1800°F would not effectively reduce the flame temperature for NO_X reduction like the 300°F to 500°F off-gas from the ESP after the calciner. Furthermore, the "product" sent from the furnace to the calciner is hot air to calcine the trona ore. Recirculating the off-gas from the furnace before going through the calciner defeats the purpose of heating the air for calcination of the trona ore.

Following is a summary table of the cost effectiveness of FGR, Water Injection (WI), and SNCR, per calciner. The Total Annualized Costs are detailed in the attached spreadsheets.

Control Technology	Total Annualized Cost	Base TPY NO_X	TPY NO_X removed	NO_X removal (%)	\$/ton NO_X removed
SNCR + FGR + WI	783,000	692	315	46	2,486
SNCR	624,000	692	315	46	1,981
FGR + WI	273,000	692	298	43	916
FGR	187,000	692	238	34	785
WI	87,000	692	60	9	1,461

Note that the annualized cost of SNCR + FGR + WI is \$783,000, which is not the same as the sum of the three controls separately of \$898,000. This is due to less reagent usage if all three controls were installed.

The following table summarized incremental costs:

Case #1	Case #2	Additional NO_X removed (TPY)	Additional annual cost ($)	Incremental cost ($/ton)
SNCR	SNCR + FGR + WI	0	159,000	N/A
FGR + WI	SNCR	17	351,000	20,647
FGR	FGR + WI	60	86,000	1,433
WI	WI + FGR	238	186,000	782

Two control scenarios, SNCR alone, and SNCR + FGR + WI result in the same NO_X reduction of 46%, or 315 tpy. This is due to the reduced effectiveness of SNCR in the presence of increased levels of CO due to FGR. The incremental cost to control the 17 additional tpy of NO_X that SNCR achieves beyond what FGR + WI achieves, is $20,647. This amount is economically unreasonable.

The incremental cost to control the 60 additional tpy of NO_X that FGR + WI achieve beyond what FGR alone achieves, is $1,433. The incremental cost to control the 238 additional tpy of NO_X that FGR + WI achieve beyond what WI alone achieves, is $782. These two incremental costs are economically reasonable.

In summary, FGR with WI is considered BACT for controlling NO_X on the proposed AQD #17 (A&B Calciners).

NOx Control Cost Estimates for
Solvay Minerals, Inc.
Calciners A & B Fuel Switch OP 30-126
AP-0631
Corrected PEC over April 2003 submittal. April submittal used 1.3 as factor for instrumentation, sales tax, freight. Correct factor is 1.18.

Main References:

CFD Modeling Stoker Fired Calciner Furnace
Detroit Stoker Company Job No. ES-111
dated 8/6/2002

Detroit Stoker Company Specifications and Proposal No. P-RG-7447-1A
dated 10/30/02

Notes:

This cost analysis is directed to addressing the incremental economic cost of controlling calciner coal furnace NOx emissions with water injection (WI) and flue gas recirculation (FGR) systems.

Solvay Soda Ash JV has determined that Detroit Stoker design calciner coal furnaces with WI and FGR are available and feasible technology with the lowest NOx emission rate.

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Basis

		Source
1	Of two calciner furnaces is used in basis of calculations	*Permit Application*
325,000	ACFM calciner offgas	*Permit Application*
156,407	SCFM @ 60F calciner offgas	*Calculated*
120,000	DSCFM @ 60F calciner offgas	*Permit Application*
400	Deg F flue gas temperatrue	*Permit Application*
200	Furnace heat input MM Btu/h (HHV)	*Detroit Stoker Specification*
1,752,000	Furnace heat input MM Btu/Y (HHV)	*Calculated from Permit Application*
5	No. of stokers each	*Detroit Stoker Specification*
100	Percent excess air in furnace	*Detroit Stoker Specification*
1,800	Furnace outlet temperature deg F	*Detroit Stoker Specification*
30	Flue Gas Recirculation (FGR) % of calciner offgas	*Detroit Stoke Specification*
50,000	Flue Gas Recirculation rate ACFM	*Calculated from Detroit Stoke Specification*
113,000	Flue Gas Recirculation rate lb/H	*Calculated from Detroit Stoke Specification*
15	Water Injection (WI) injection rate gpm	*Detroit Stoke Specification*
10,000	Water Injection injection rate lb/H	*Calculated from Detroit Stoke Specification*
11.70	Ambient atmos pressure, psia	*Ambient Pressure Data*
14.70	Std atmos pressure	*Standard Atmospheric Pressure*
$	Dollars expressed in USD	

Total Equipment

2	Bigelow-Liptak refractory lined furnaces with Detroit Stoker RotoGrate Stokers. handling calcined ore (soda ash) dust (90 - 95%), fly ash, silica, shale, shortite (5 - 10%)	*Proposal No. P-RG-7447-1A, October 30, 2002*
2	Overfire Air Turbulence System (standard)	*Proposal No. P-RG-7447-1A, October 30, 2002*
2	Flue Gas Recirculation System	*Proposal No. P-RG-7447-1A, October 30, 2002*
2	Water Injection System	*Proposal No. P-RG-7447-1A, October 30, 2002*

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Performace to Achieve 0.45 lb Nox / MM Btu

0.79	Nox emission rate revised OFA configuration lb/MM Btu Input	*Permit Application and Proposal P-RG-7447-1A, 10/30/02*
0.518	Nox emission rate with FGR lb/MM Btu input	*Calculated, DSC 4/24/2003, 80% NOx reduction due FGR*
0.45	Nox emission rate with FGR + WI lb/MM Btu input	*Detroit Stoker Emission Guarantee with FGR and WI*
692	Nox emission rate revised OFA configuration, tons/Y	*Calculated*
238	Nox emission reduction with FGR, tons/Y	*Calculated*
60	Nox emission reduction with WI, tons/Y	*Calculated*
298	Total Nox emission reduction, tons/Y	*Calculated*
788	Resulting total Nox emission, two calciners, tons/Y	*Permit Application*

Cost Estimates of Nox Reduction Equipment to Achieve 0.45 lb Nox / MM Btu

Equipment Cost FGR System

277,694	FGR System equipment cost, undergrate and overfire air, inc. fans, motors, dampers, ductwork, supports, manifolds and nozzles.	*DSC 4/24/2003; Proposal P-RG-7447-1A, 10/30/2002*
1.3	Factor for retrofit (1.3 to 1.5 is suggested, based on difficulty)	*EPA Air Pollution Cost Manual*
361,002	Adjusted equipment cost for retrofit	*Calculated*
1.18	Factor for instrumentation, sales tax, freight	*EPA Air Pollution Cost Manual*
425,982	Purchased equipment cost, PEC	*Calculated*

Auxilliaries Cost

0	None	*Estimated*

Total Capital Investment

2.24	Factor for direct and indirect installation costs (DC + IC) (Based on the new equipment fitting existing space. Site preparation and building costs are assumed to be negligible.)	*EPA Air Pollution Cost Manual*
954,199	**Total Capital Investment TCI (FGR each furnace)**	*Calculated*

Annual Costs Pressure Drop, Moving FGR from ID Fan Breech to Furnace

200	FGR fan power consumption, HP	*DSC 4/24/2003; Proposal P-RG-7447-1A, 10/30/2002*
0.7457	KW consumption / HP	*Unit Conversion*
1,306,466	KWH/Y	*Calculated*
0.0345	Electrical rate, $/KWH	*Solvay 2003 YTD actual cost*
45,073	Annual power cost for FGR	*Calculated*

Total Annual Cost

	DIRECT	
0	Operating labor -- negligible	*Estimated*
4,000	Maintenance labor four persons 20 hr/Y, $50/Hr.	*Estimated*
4,260	Maintenance material 1% of PEC	*EPA Air Pollution Cost Manual*
8,260	Total Direct Cost (DC)	
	INDIRECT	
4,956	Overhead 60% of op labor, maint labor, and maintenance material	*EPA Air Pollution Cost Manual*
19,084	Administrative charges 2% of total capital investment TCI	*EPA Air Pollution Cost Manual*
9,542	Property tax 1% of TCI	*EPA Air Pollution Cost Manual*
9,542	Insurance 1% of TCI	*EPA Air Pollution Cost Manual*
	EPA Section 1, Chapter 2, page 2-21	*EPA Air Pollution Cost Manual*
	Life of project n 20 years	*EPA Air Pollution Cost Manual*
	Interest rate = 7 %	*Interest rate per Stephen Kovar, Solvay Minerals, Inc.*
	CRF = i(1 +i)nth power/((1 + i)nth power -1)	*EPA Air Pollution Cost Manual*
	1 + i = 1.07	*Calculated*
	CRF = 0.094393	*Calculated*
90,070	Capital recovery assuming 0.09439 , interest = 7 %	*Calculated*
133,194	Total Indirect Cost (IC)	
186,526	**Total Annual Cost FGR (each furnace)**	
187,000	**Total Annual Cost FGR (rounded, each furnace)**	

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Equipment Cost WI System

39,584	WI System equipment cost, including header solenoid valves, and spray nozzles. (system will use existing plant water pump)			*DSC 4/24/2003; Proposal P-RG-7447-1A, 10/30/2002*
1.3	Factor for retrofit (1.3 to 1.5 is suggested, based on difficulty)			*EPA Air Pollution Cost Manual*
51,459	Adjusted equipment cost for retrofit			*Calculated*
1.18	Factor for instrumentation, sales tax, freight			*EPA Air Pollution Cost Manual*
60,721	Purchased equipment cost, PEC			*Calculated*

Auxilliaries Cost

0	None			*Estimated*

Total Capital Investment

2.24	Factor for direct and indirect installation costs (DC + IC) (Based on the new equipment fitting existing space. Site preparation and building costs are assumed to be negligible.)			*EPA Air Pollution Cost Manual*
136,015	**Total Capital Investment TCI (WI each furnace)**			*Calculated*

Annual Costs Evaporation and Pumping of Water to Furnace

	PUMPING			
15	GPM water flow			*DSC 4/24/2003; Proposal P-RG-7447-1A, 10/30/2002*
2	Pump power consumption, HP			*Pump manual*
0.7457	KW consumption / HP			*Standard conversion*
13,065	KWH/Y			*Calculated*
0.0345	Electrical rate, $/KWH			*Solvay 2003 YTD actual cost*
451	Annual power cost for water pump			*Calculated*
	EVAPORATION			
15	Water Injection GPM flow			*DSC Proposal No. P-RG-7447-1A, October 30, 2002*
	Calciner Energy Consumption *	w/Water Injection	w/o Water Injection	*Solvay Material and Energy Balance:*
	Purchased MMBTU/Ton Ore	1.158	1.1074	*Solvay Material and Energy Balance:*
	* for the same furnace offgas temperature.			
	Fuel cost $/ton coal	22.00	22.00	
	Fuel cost $/ton ore	1.23	1.18	
	Fuel Cost $/Day	4719	4513	
	Fuel cost $/Y	1,463,974	1,400,192	
63,782	Annual Water Injection Energy Cost Compared to Standard Furnace			

Total Annual Cost

	DIRECT	
0	Operating labor -- negligible	*Estimated*
2,000	Maintenance labor two persons 20 hr/Y, $50/Hr.	*Estimated*
607	Maintenance material 1% of PEC	*EPA Air Pollution Cost Manual*
2,607	Total Direct Cost (DC)	
	INDIRECT	
1,564	Overhead 60% of op labor, maint labor, and maintenance material	*EPA Air Pollution Cost Manual*
2,720	Administrative charges 2% of total capital investment TCI	*EPA Air Pollution Cost Manual*
1,360	Property tax 1% of TCI	*EPA Air Pollution Cost Manual*
1,360	Insurance 1% of TCI	*EPA Air Pollution Cost Manual*
	EPA Section 1, Chapter 2, page 2-21	*EPA Air Pollution Cost Manual*
	Life of project n 20 years	*EPA Air Pollution Cost Manual*
	Interest rate = 7 %	*Interest rate per Stephen Kovar, Solvay Minerals, Inc.*
	CRF = i(1 +i)nth power/((1 + i)nth power -1)	*EPA Air Pollution Cost Manual*
	1 + i = 1.07	*Calculated*
	CRF = 0.094393	*Calculated*
12,839	Capital recovery assuming ' 0.09439 , interest = 7 %	*Calculated*
19,844	Total Indirect Cost (IC)	
86,684	**Total Annual Cost WI (each furnace)**	
87,000	**Total Annual Cost WI (rounded, each furnace)**	

SUMMARY

Nox Emissions

692	Base Nox emission rate, tons/Y	*Calculated*
238	Nox emission reduction with FGR, tons/Y	*Calculated*
60	Nox emission reduction with WI, tons/Y	*Calculated*
298	Total Nox emission reduction, tons/Y	*Calculated*
187,000	**Total Annual Cost FGR (rounded, each furnace)**	*Calculated*
87,000	**Total Annual Cost WI (rounded, each furnace)**	*Calculated*

Cost Effectiveness

$785	**USD per ton of Nox removed, FGR**	*Calculated*
$1,461	**USD per ton of Nox removed, WI**	*Calculated*

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	Cost SNCR System	*Reference:*
565,000	SNCR system equipment cost -- supports, manifolds, pumps, piping and nozzles	*Fuel Tech Commercial Proposal No. 03-C-084 (w/o FGR), 12/8/03*
1.3	Factor for retrofit (1.3 to 1.5 is suggested, based on difficulty)	*EPA Air Pollution Cost Manual. Difficult retrofit due to conjested area.*
734,500	Adjusted equipment cost for retrofit	*Calculated*
1.18	Factor for instrumentation, sales tax, freight	*EPA Air Pollution Cost Manual*
866,710	Purchased equipment cost, PEC	*Calculated*

Auxilliaries Cost

0	None	*Estimated*

Total Capital Investment

2.24	Factor for direct and indirect installation costs (DC + IC) (Based on the new equipment fitting existing space. Site preparation and building costs are assumed to be negligible.)	*EPA Air Pollution Cost Manual*
1,941,430	**Total Capital Investment TCI (SNCR each furnace)**	*Calculated*

Annual Costs Evaporation and Pumping of Water to Furnace

	PUMPING	
40.0	Urea flow, GPH	*Fuel Tech Commercial Proposal No. 03-C-084 (w/o FGR), 12/8/03*
5	Pump power consumption, HP	*Estimate*
0.7457	KW consumption / HP	*Standard conversion*
32,662	KWH/Y	*Calculated*
0.0345	Electrical rate, $/KWH	*Solvay 2003 YTD actual cost*
1,127	Annual power cost for urea pumps	*Calculated*

Annual Costs Urea Reagent Cost, NoxOUT A

40	Urea consumption, gal/h	*Fuel Tech Commercial Proposal No. 03-C-084, Rev 1, 10/6/03*
350,400	Urea consumption, gal/y	*Calculated*
50	Urea composition %	*Fuel Tech Commercial Proposal No. 03-C-084, Rev 1, 10/6/03*
1.14	Urea spec gravity	*NoxOUT A specifications*
190.2	Pure urea consumption, lb/hr	*Calculated*
1.11	Urea cost, $/gal delivered	*Noxout A quotation from Agrium, 10/27/03*
0.12	Urea cost, $/lb solution delivered	*Noxout A quotation from Agrium, 10/27/03*
233.50	Urea cost, $/ton solution delivered	*Noxout A quotation from Agrium, 10/27/03*
330,602	Urea cost, $/year per calciner	*Calculated*

Total Annual Cost

	DIRECT	
0	Operating labor -- negligible	*Estimated*
7,500	Maintenance labor three persons 50 hr/Y, $50/Hr.	*Estimated*
8,667	Maintenance material 1% of PEC	*EPA Air Pollution Cost Manual*
16,167	Total Direct Cost (DC)	
	INDIRECT	
9,700	Overhead 60% of op labor, maint labor, and maintenance material	*EPA Air Pollution Cost Manual*
38,829	Administrative charges 2% of total capital investment TCI	*EPA Air Pollution Cost Manual*
19,414	Property tax 1% of TCI	*EPA Air Pollution Cost Manual*
19,414	Insurance 1% of TCI	*EPA Air Pollution Cost Manual*
	EPA Section 1, Chapter 2, page 2-21	*EPA Air Pollution Cost Manual*
	Life of project n = 20 years	*EPA Air Pollution Cost Manual*
	Interest rate = 7 %	*Interest rate per Stephen Kovar, Solvay Minerals, Inc.*
	CRF = i(1 +i)nth power/((1 + i)nth power -1)	*EPA Air Pollution Cost Manual*
	1 + i = 1.07	*Calculated*
	CRF = 0.094393	*Calculated*
183,257	Capital recovery assuming CRF = 0.09439 , interest = 7 %	*Calculated*
270,615	Total Indirect Cost (IC)	
1,127	Total Annual Cost Electricity, pumps	*Calculated*
5,000	Calciner Energy, evaporate 50% Urea solution	*Estimate*
330,602	Total Annual Cost, Reagent	*Calculated*
623,511	**Total Annual Cost SNCR (each furnace)**	
624,000	**Total Annual Cost SNCR (rounded, each furnace)**	

SUMMARY

Nox Emissions

692	Base Nox emission rate, tons/Y based on 0.79 lb/MMBtu
315	Nox emission reduction with SNCR, tons/Y based on 0.43 lb /MMBtu

Cost Effectiveness

$1,981 **USD per ton of Nox removed, SNCR**

Cost FGR + WI + SNCR, 1500 ppm CO

		Reference:
1	Number of calciners used as basis of calculations, out of two total, identical	*Basis of Calculations*
882,277	FGR + WI + SNCR System equipment cost, undergrate and overfire air, inc. fans, motors, dampers, ductwork, supports, manifolds, pumps, piping and nozzles, +SNCR equipment	*Detroit Stoker Letter 4/24/03, and Proposal No. P-RG-7447-1A, 10/30/02 and Fuel Tech Commercial Proposal No. 03-C-084, Rev 4, 12/8/03*
1.3	Factor for retrofit (1.3 to 1.5 is suggested, based on difficulty)	*EPA Air Pollution Cost Manual. Difficult retrofit due to conjested area.*
1,146,960	Adjusted equipment cost for retrofit	*Calculated*
1.18	Factor for instrumentation, sales tax, freight	*EPA Air Pollution Cost Manual*
1,353,413	Purchased equipment cost, PEC	*Calculated*

Auxilliaries Cost

0	None	*Estimated*

Total Capital Investment

2.24	Factor for direct and indirect installation costs (DC + IC) (Based on the new equipment fitting existing space. Site preparation and building costs are assumed to be negligible.)	*EPA Air Pollution Cost Manual*
3,031,645	**Total Capital Investment TCI (FGR + WI + SNCR each furnace)**	*Calculated*

Annual Costs Pressure Drop, Moving FGR from ID Fan Breech to Furnace

200	FGR fan power consumption, HP	*Detroit Stoker Letter 4/24/03, and Proposal No. P-RG-7447-1A, 10/30/02*
0.7457	KW consumption / HP	*Unit Conversion*
1,306,466	KWH/Y	*Calculated*
0.0345	Electrical rate, $/KWH	*Solvay 2003 YTD actual cost*
45,073	Annual power cost for FGR	*Calculated*

Annual Costs Evaporation and Pumping of Water to Furnace

	PUMPING	
15	Water GPM	*Detroit Stoker Letter 4/24/03, and Proposal No. P-RG-7447-1A, 10/30/02*
25.9	Urea flow, NoxOUT A, GPH	*Fuel Tech Commercial Proposal No. 03-C-084, Rev 1, 10/6/03*
10	Pump power consumption, HP	*Pump manual*
0.7457	KW consumption / HP	*Standard conversion*
65,323	KWH/Y	*Calculated*
0.0345	Electrical rate, $/KWH	*Solvay 2003 YTD actual cost*
2,254	Annual power cost for water and urea pumps	*Calculated*

	EVAPORATION			
15	Water Injection GPM flow			*Detroit Stoker Proposal No. P-RG-7447-1A, October 30, 2002*
	Calciner Energy Consumption *	w/Water Injection	w/o Water Injection	*Solvay Material and Energy Balance:*
	Purchased MMBTU/Ton Ore	1.158	1.1074	H:\Calciners to Coal\MebcoalcalcFGRWI.xls
	* for the same furnace offgas temperature.			
	Fuel cost $/ton coal	22.00	22.00	*Solvay Monthly Energy Reports*
	Coal MM Btu/ton coal	20.66	20.66	*Calculated*
	Fuel cost $/MM Btu	1.065	1.065	*Calculated*
	Fuel cost $/ton ore	1.23	1.18	*Calculated*
	Fuel Cost $/Day	4719	4719	*Calculated*
	Ore rate tons/day	3826	3826	*Permit application*
	Fuel cost $/day calc	4719	4513	*Calculated*
	Fuel cost $/Y	1,463,974	1,400,192	*Calculated with 85% onstream factor*
5,000	Annual Urea water evaporatation Coal Energy Cost compared to standard furnace			*Estimate*
68,782	Annual Water Injection Coal Energy Cost Compared to Standard Furnace			*Calculated*

Annual Costs Urea Reagent Cost, NoxOUT A

25.9	Urea consumption, gal/h	*Fuel Tech Commercial Proposal No. 03-C-084, Rev 1, 10/6/03*
226,884	Urea consumption, gal/y	*Calculated*
50	Urea composition %	*Fuel Tech Commercial Proposal No. 03-C-084, Rev 1, 10/6/03*
1.14	Urea spec gravity	*NoxOUT A specifications*
123.1	Pure urea consumption, lb/hr	*Calculated*
1.11	Urea cost, $/gal delivered	*Noxout A quotation from Agrium, 10/27/03*
0.12	Urea cost, $/lb solution delivered	*Noxout A quotation from Agrium, 10/27/03*
233.50	Urea cost, $/ton solution delivered	*Noxout A quotation from Agrium, 10/27/03*
214,065	Urea cost, $/year per calciner	*Calculated*

Total Annual Cost

	DIRECT	
0	Operating labor -- negligible	*Estimated*
15,000	Maintenance labor six persons 50 hr/Y, $50/Hr.	*Estimated*
13,534	Maintenance material 1% of PEC	*EPA Air Pollution Cost Manual*
28,534	Total Direct Cost (DC)	
	INDIRECT	
17,120	Overhead 60% of op labor, maint labor, and maintenance material	*EPA Air Pollution Cost Manual*
60,633	Administrative charges 2% of total capital investment TCI	*EPA Air Pollution Cost Manual*
30,316	Property tax 1% of TCI	*EPA Air Pollution Cost Manual*
30,316	Insurance 1% of TCI	*EPA Air Pollution Cost Manual*

EPA Section 1, Chapter 2, page 2-21			*EPA Air Pollution Cost Manual*
Life of project n =	20	years	*EPA Air Pollution Cost Manual*
Interest rate =	7	%	*Interest rate per Stephen Kovar, Solvay Minerals, Inc.*
CRF = i(1 +I)nth power/((1 + I)nth power -1)			*EPA Air Pollution Cost Manual*
1 + I =	1.07		*Calculated*
CRF =	0.094393		*Calculated*

286,166	Capital recovery assuming CRF = 0.09439 , interest = 7 %	*Calculated*
424,552	Total Indirect Cost (IC)	
47,327	Total Annual Cost Electricity, fans + pumps	
68,782	Total Annual Cost, Coal, Calciner Energy	
214,065	Total Annual Cost, Reagent	
783,260	**Total Annual Cost FGR + WI + SNCR, 1500 ppm CO, (each furnace)**	
783,000	**Total Annual Cost FGR + WI + SNCR, 1500 ppm CO, (rounded, each furnace)**	

SUMMARY

Nox Emissions

692 Base Nox emission rate, tons/Y based on 0.79 lb/MMBtu
315 NOx emission reduction with FGR + WI + SNCR, tons/Y based on 0.43 lb /MMBtu

Cost Effectiveness

$2,486 USD per ton of Nox removed, FGR, WI, SNCR, 1500 ppm CO

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Cost Estimates of NOx Reduction Options, Equipment

	Cost FGR + WI System	Reference:
1	Number of calciners used as basis of calculations, out of two total, identical	*Basis of calculations*
317,277	FGR + WI System equipment cost, undergrate and overfire air, inc. fans, motors, dampers, ductwork, supports, manifolds, pumps, piping and nozzles.	*Detroit Stoker Letter 4/24/03, and Proposal No. P-RG-7447-1A, 10/30/02*
1.3	Factor for retrofit (1.3 to 1.5 is suggested, based on difficulty)	*EPA Air Pollution Cost Manual. Difficult retrofit due to conjested area.*
412,460	Adjusted equipment cost for retrofit	*Calculated*
1.18	Factor for instrumentation, sales tax, freight	*EPA Air Pollution Cost Manual*
486,703	Purchased equipment cost, PEC	*Calculated*

Auxilliaries Cost

0	None	*Estimated*

Total Capital Investment

2.24	Factor for direct and indirect installation costs (DC + IC) (Based on the new equipment fitting existing space. Site preparation and building costs are assumed to be negligible.)	*EPA Air Pollution Cost Manual*
1,090,215	**Total Capital Investment TCI (FGR + WI each furnace)**	*Calculated*

Annual Costs Pressure Drop, Moving FGR from ID Fan Breech to Furnace

200	FGR fan power consumption, HP	*Detroit Stoker Letter 4/24/03, and Proposal No. P-RG-7447-1A, 10/30/02*
0.7457	KW consumption / HP	*Unit Conversion*
1,306,466	KWH/Y	*Calculated*
0.0345	Electrical rate, $/KWH	*Solvay 2003 YTD actual cost*
45,073	Annual power cost for FGR	*Calculated*

Annual Costs Evaporation and Pumping of Water to Furnace

	PUMPING	
15	GPM water flow	*Detroit Stoker Letter 4/24/03, and Proposal No. P-RG-7447-1A, 10/30/02*
2	Pump power consumption, HP	*Pump manual*
0.7457	KW consumption / HP	*Standard conversion*
13,065	KWH/Y	*Calculated*
0.0345	Electrical rate, $/KWH	*Solvay 2003 YTD actual cost*
451	Annual power cost for water pump	*Calculated*

	EVAPORATION			
15	Water Injection GPM flow			*Detroit Stoker Proposal No. P-RG-7447-1A, October 30, 2002*
	Calciner Energy Consumption *	w/Water Injection	w/o Water Injection	*Solvay Material and Energy Balance:*
	Purchased MMBTU/Ton Ore	1.158	1.1074	H:\Calciners to Coal\MebcoalcalcFGRWI.xls
	* for the same furnace offgas temperature.			
	Fuel cost $/ton coal	22.00	22.00	*Solvay Monthly Energy Reports*
	Coal MM Btu/ton coal	20.66	20.66	*Calculated*
	Fuel cost $/MM Btu	1.065	1.065	*Calculated*
	Fuel cost $/ton ore	1.23	1.18	*Calculated*
	Fuel Cost $/Day	4719	4719	*Calculated*
	Ore rate tons/day	3826	3826	*Permit application*
	Fuel cost $/day calc	4719	4513	*Calculated*
	Fuel cost $/Y	1,463,974	1,400,192	*Calculated with 85% onstream factor*
63,782	Annual Water Injection Coal Energy Cost Compared to Standard Furnace			

Total Annual Cost

	DIRECT	
0	Operating labor -- negligible	*Estimated*
6,000	Maintenance labor six persons 20 hr/Y, $50/Hr.	*Estimated*
4,867	Maintenance material 1% of PEC	*EPA Air Pollution Cost Manual*
10,867	Total Direct Cost (DC)	
	INDIRECT	
6,520	Overhead 60% of op labor, maint labor, and maintenance material	*EPA Air Pollution Cost Manual*
21,804	Administrative charges 2% of total capital investment TCI	*EPA Air Pollution Cost Manual*
10,902	Property tax 1% of TCI	*EPA Air Pollution Cost Manual*
10,902	Insurance 1% of TCI	*EPA Air Pollution Cost Manual*
	EPA Section 1, Chapter 2, page 2-21	*EPA Air Pollution Cost Manual*
	Life of project n = 20 years	*EPA Air Pollution Cost Manual*
	Interest rate = 7 %	*Interest rate per Stephen Kover, Solvay Minerals, Inc.*
	CRF = i(1 +i)nth power/((1 + i)nth power -1)	*EPA Air Pollution Cost Manual*
	1 + i = 1.07	*Calculated*
	CRF = 0.094393	*Calculated*
102,909	Capital recovery assuming CRF = 0.09439 , interest = 7 %	*Calculated*
153,037	Total Indirect Cost (IC)	
45,524	Total Annual Cost Electricity, fans + pumps	
63,782	Total Annual Cost Coal, Calciner Energy	
0	Reagent	

273,210	**Total Annual Cost FGR + WI (each furnace)**
273,000	**Total Annual Cost FGR + WI (rounded, each furnace)**

SUMMARY

<u>Nox Emissions</u>

692	Base Nox emission rate, tons/Y based on 0.79 lb/MMBtu
298	NOx emission reduction with FGR + WI, tons/Y based on 0.45 lb /MMBtu

<u>Cost Effectiveness</u>

$916	**USD per ton of Nox removed, FGR + WI**

CEM Data
Run 1

Date	5/4/00
Time	CO (ppm)
Average	507.3
9:27:46	483.9
9:28:47	476.1
9:29:47	485.6
9:30:46	484.5
9:31:47	489.9
9:32:47	487.3
9:33:46	489.8
9:34:47	473.5
9:35:47	483.3
9:36:46	481.7
9:37:46	474.7
9:38:47	473.7
9:39:46	474.1
9:40:46	473.8
9:41:47	470.2
9:42:46	475.7
9:43:46	478.1
9:44:47	472.5
9:45:47	476.2
9:46:46	484.5
9:47:47	482.9
9:48:47	479.0
9:49:46	486.7
9:50:47	480.6
9:51:47	482.3
9:52:46	477.9
9:53:46	489.7
9:54:47	485.5
9:55:46	491.2
9:56:46	494.0
9:57:47	495.7
9:58:46	496.7
9:59:46	501.8
10:00:47	502.2
10:01:47	504.0
10:02:46	497.6
10:03:47	507.2
10:04:47	514.7
10:05:46	518.2
10:06:47	516.8
10:07:47	525.8
10:08:46	525.8
10:09:46	532.0
10:10:47	533.2
10:11:46	535.4
10:12:46	542.1
10:13:47	549.1
10:14:47	554.4
10:15:46	550.9
10:16:47	554.1
10:17:47	550.6
10:18:46	552.2
10:19:47	552.3
10:20:47	545.9
10:21:46	548.0
10:22:46	551.4
10:23:47	547.7
10:24:46	545.4
10:25:46	543.2
10:26:47	546.8
10:27:46	563.8

Solvay Minerals, Inc.
CA-1 2 Stack

CEM Data
Run 2

Project No. 1325-3

Date	5/4/00
Time	CO (ppm)
Average	505.8

10:41:35	507.8
10:42:36	511.6
10:43:36	511.2
10:44:35	504.8
10:45:36	499.5
10:46:36	496.4
10:47:35	505.9
10:48:35	506.5
10:49:36	507.4
10:50:35	502.7
10:51:35	489.0
10:52:36	479.9
10:53:35	487.1
10:54:35	492.0
10:55:36	481.2
10:56:36	481.0
10:57:35	472.0
10:58:36	470.5
10:59:36	468.1
11:00:35	470.8
11:01:36	464.7
11:02:36	477.8
11:03:35	478.5
11:04:35	477.2
11:05:36	482.0
11:06:35	474.0
11:07:35	474.5
11:08:36	484.7
11:09:35	483.0
11:10:35	487.6
11:11:36	482.3
11:12:36	481.6
11:13:35	476.1
11:14:36	470.0
11:15:36	466.8
11:16:35	482.4
11:17:36	494.0
11:18:36	490.4
11:19:35	493.2
11:20:35	496.6
11:21:36	495.4
11:22:35	495.8
11:23:35	505.9
11:24:36	507.7
11:25:36	499.1
11:26:36	506.4
11:27:36	508.6
11:28:36	513.1
11:29:36	513.3
11:30:36	512.0
11:31:36	524.5
11:32:36	524.0
11:33:36	532.1
11:34:36	542.4
11:35:36	556.5
11:36:36	573.2
11:37:36	594.5
11:38:36	605.1
11:39:36	618.1
11:40:36	626.7
11:41:36	635.0

Solvay Minerals, Inc.
CA-1 2 Stack

CEM Data
Run 3

Project No. 1325-3

Date	5/4/00
Time	CO (ppm)
Average	965.1

11:55:01	784.2
11:56:01	777.1
11:57:01	787.9
11:58:01	788.4
11:59:01	779.2
12:00:01	781.9
12:01:01	778.1
12:02:01	765.5
12:03:01	765.0
12:04:01	748.0
12:05:01	744.7
12:06:01	743.6
12:07:01	734.0
12:08:01	738.1
12:09:01	738.8
12:10:01	736.6
12:11:01	725.3
12:12:01	727.4
12:13:01	726.3
12:14:01	740.6
12:15:01	737.2
12:16:01	756.4
12:17:01	760.5
12:18:01	776.3
12:19:01	786.3
12:20:01	802.9
12:21:01	834.8
12:22:01	850.6
12:23:01	873.5
12:24:01	890.7
12:25:01	894.1
12:26:01	905.7
12:27:01	892.4
12:28:01	923.9
12:29:01	930.0
12:30:01	920.2
12:31:01	899.1
12:32:01	877.9
12:33:01	875.1
12:34:01	849.0
12:35:01	857.2
12:36:01	859.3
12:37:01	858.5
12:38:01	877.9
12:39:01	889.2
12:40:01	922.7
12:41:01	940.2
12:42:01	968.1
12:43:01	1015.2
12:44:01	1097.1
12:45:01	1221.6
12:46:01	1336.9
12:47:01	1429.5
12:48:01	1560.8
12:49:01	1638.4
12:50:01	1679.6
12:51:01	1726.3
12:52:01	1772.1
12:53:01	1750.1
12:54:01	1707.9
12:55:01	1612.6